Phase 3 Hydraulic Analysis of China Camp Creek Restoration Project

Prepared for:

Nehalem Marine Manufacturing Inc. and

Beaver Slough Dike District

Prepared by:

Northwest Hydraulic Consultants

Seattle, WA

September 2013

This report has been prepared by Vaughn Collins, P.E

Acknowledgements

The following staff of Northwest Hydraulic Consultants participated in this study:

Jaron Brown, P.E. Field Survey

We gratefully acknowledge the assistance of the following individuals for providing project information:

Fred Messerle Beaver Slough Drainage District

Leo Kuntz Nehalem Marine

Vertical Datum

All elevations herein are expressed in NAVD88 vertical datum.

Conventions

References to “Left bank” or “Right bank” are based on the observer facing in a downstream direction.

Table of Contents

List of Figures

List of Tables

1 Purpose

Northwest Hydraulic Consultants Inc. (NHC) has been contracted by Nehalem Marine Manufacturing, Inc., under the direction of the Beaver Slough Drainage District (BSDD) for hydraulic analysis of the China Camp Creek Restoration (C3R) Project near Coquille, OR. This report documents the development, calibration, and application of a hydraulic model in support of the proposed floodplain restoration design. Field survey efforts and development of project hydrology are also described.

The purpose of the model is to evaluate changes to river channel and floodplain hydraulics within and adjacent to the restoration site as a result of the project. The model was also used to evaluate various gate structure sizes, characterize culvert velocities under various tide and flow conditions, and determine water surface elevations for inundation mapping based on different operation scenarios. Initial results for low flow conditions and a limited range of gate sizes and water level regulation controls are presented here. The C3R project design is an ongoing effort and will require further modeling, including modeling of flood flows.

2 Project Proposal

The C3R project proposes to restore a portion of floodplain within the BSDD. The district has been divided into three units for project planning purposes, with restoration activities occurring in Unit 2 (Figure 1). The proposed project would hydraulically isolate Unit 2 from the rest of the district during late spring into the fall through the use of low berms along its perimeter and a new control structure at the outlet to the Coquille River. This will allow the restored area to function as a regulated tidal wetland while allowing current land uses to continue in the rest of the district. Regulation of water levels in the restored area is to be accomplished through the use of self-regulating tidegates, specifically Nehalem Marine Muted Tidal Regulators (MTRs). Units 1 and 3 will be managed for continued agricultural use using new tidegated control structures. During the winter months, the entire district is generally inundated and the proposed project would have little impact on site hydraulics.

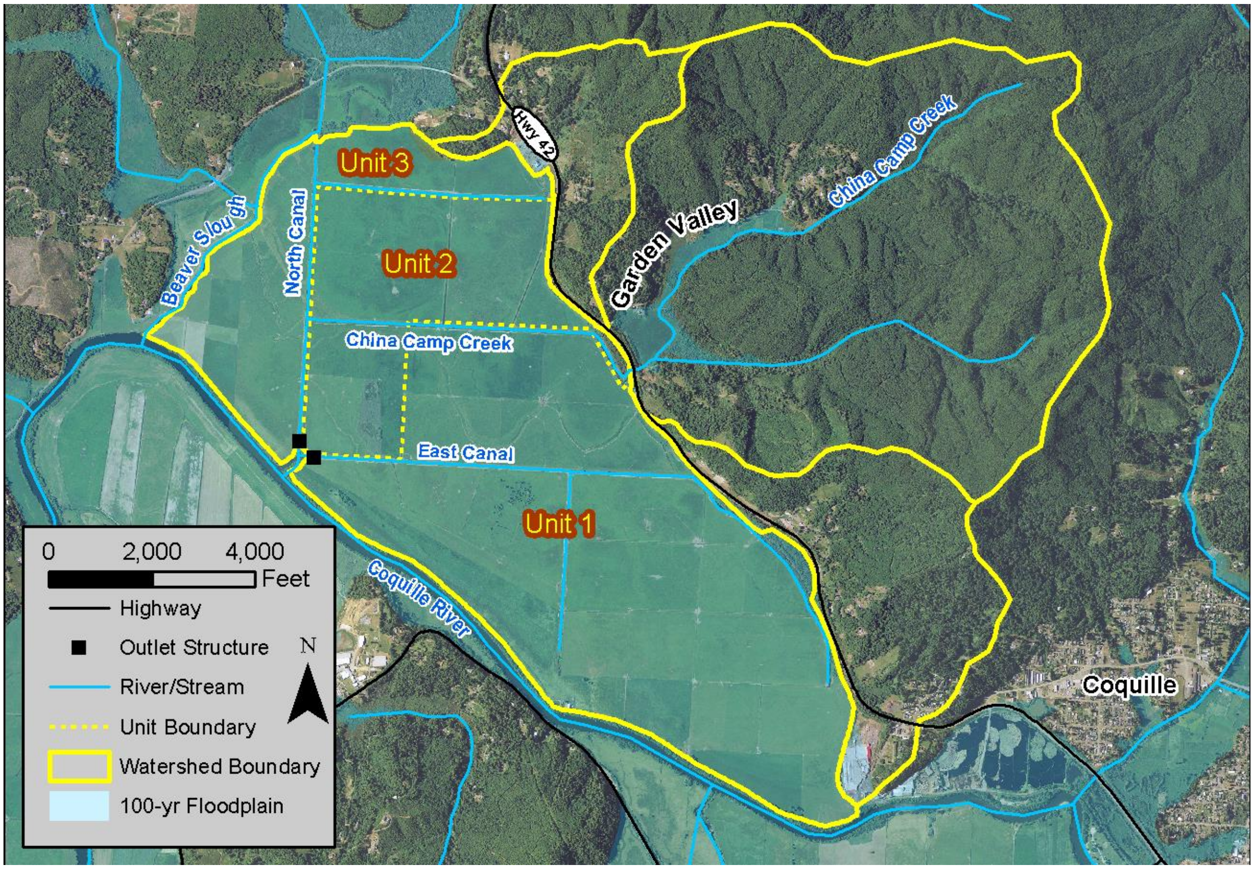

Figure 1: Project area map

3 Existing Conditions

The project area consists of the right bank floodplain of the Coquille River between the town of Coquille and Beaver Slough at approximately River Mile (RM) 20 on the mainstem Coquille River (Figure 2). The Coquille River watershed at the project site is approximately 950 square miles in area. China Camp Creek is a small tributary stream originating in mostly forested hills northeast of the project site. It flows through the Garden Valley area before crossing under Highway 42 and entering the Coquille River floodplain (Figure 1). Approximately 1.1 square miles of additional hillside area drains directly onto the floodplain. The floodplain area is managed primarily for summer cattle grazing and is mostly pasture. Within the floodplain China Camp Creek is channelized. It joins the North Canal and then flows to an outlet structure near the Coquille River. A second outlet structure collects drainage via the East Canal from the southern portion of the project area. The primary canals are bounded by low spoil berms on either side. Secondary ditches, most of which are also tide-gated, drain the pasture areas into the canals.

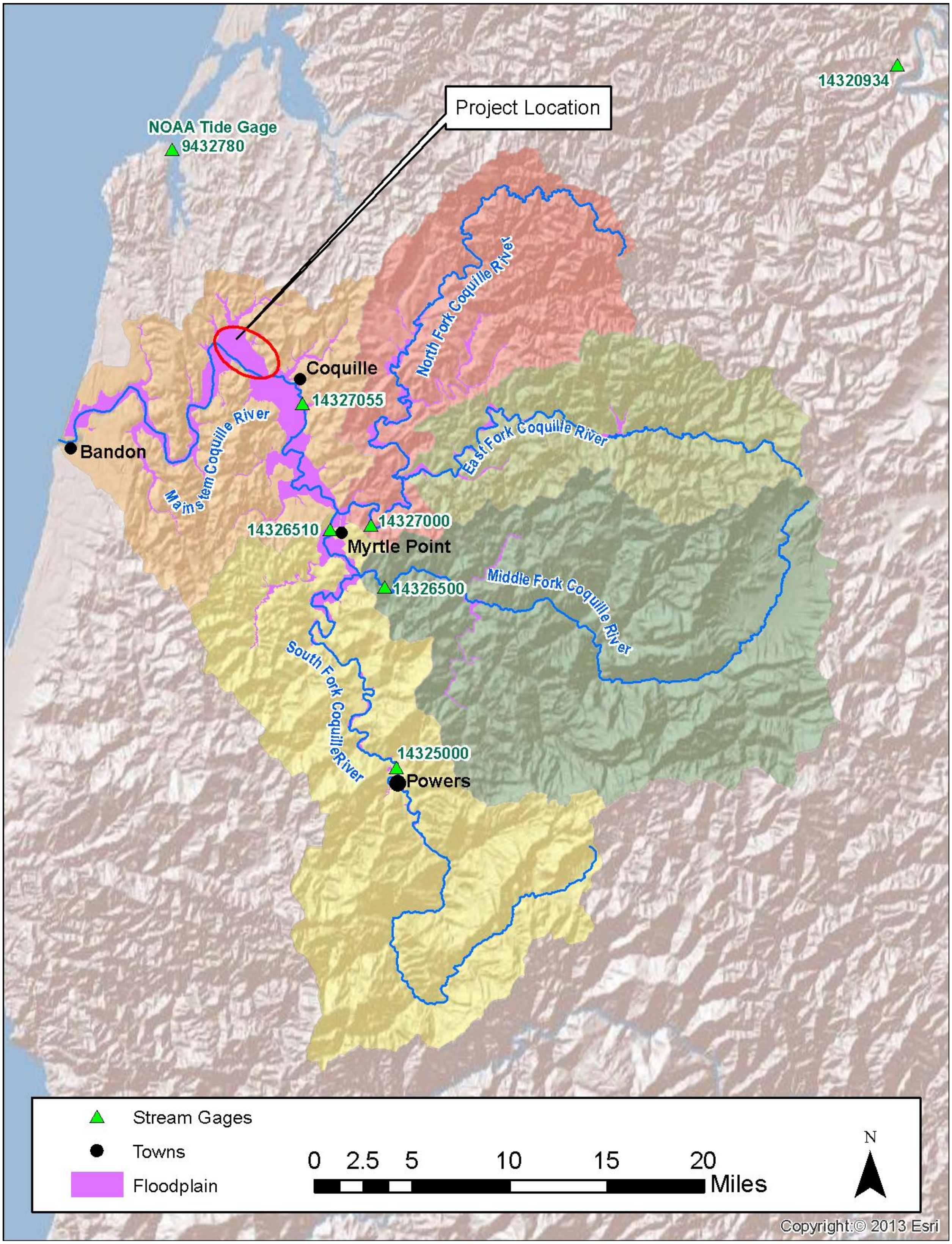

Figure 2: Coquille River Watershed

3.1 Topography

Land elevations within BSDD range from over 20 feet at the southern extent to below 3 feet in the north (Figure 3). The lower end of Garden Valley has elevations similar to the main floodplain area. Natural levees are apparent along the Coquille River, Beaver Slough, and relict channels within BSDD (Figure 3 & Figure 4). The apparent height of these levees has been accentuated by the likely subsidence of most of the floodplain away from the main channels, as is typical of many diked lands near the mouths of rivers in the Pacific Northwest. Typically natural levees along channels tend to be composed of larger, sand size sediments that are less prone to subsidence, whereas the areas farther away were historically most likely freshwater tidal wetlands. These areas typically are underlain with organic silts and clays which are highly compressible when diked and drained. Assuming that minimum floodplain elevations historically would be around the mean higher-high water (MHHW) elevation of 7 feet, most of the district has subsided by at least two to three feet.

Where Beaver Slough flows into the Coquille River it in essence “breaches” the mainstem’s natural levee. Under natural conditions this would allow backwater flooding of the district at fairly low flows during higher high tides. To prevent this a berm has been constructed along the left bank of Beaver Slough between the Coquille River and valley wall to the northwest. While this berm reduces the frequency of flooding, its elevation is lower than the Coquille River natural levees, hence flooding of the district first occurs by overtopping here.

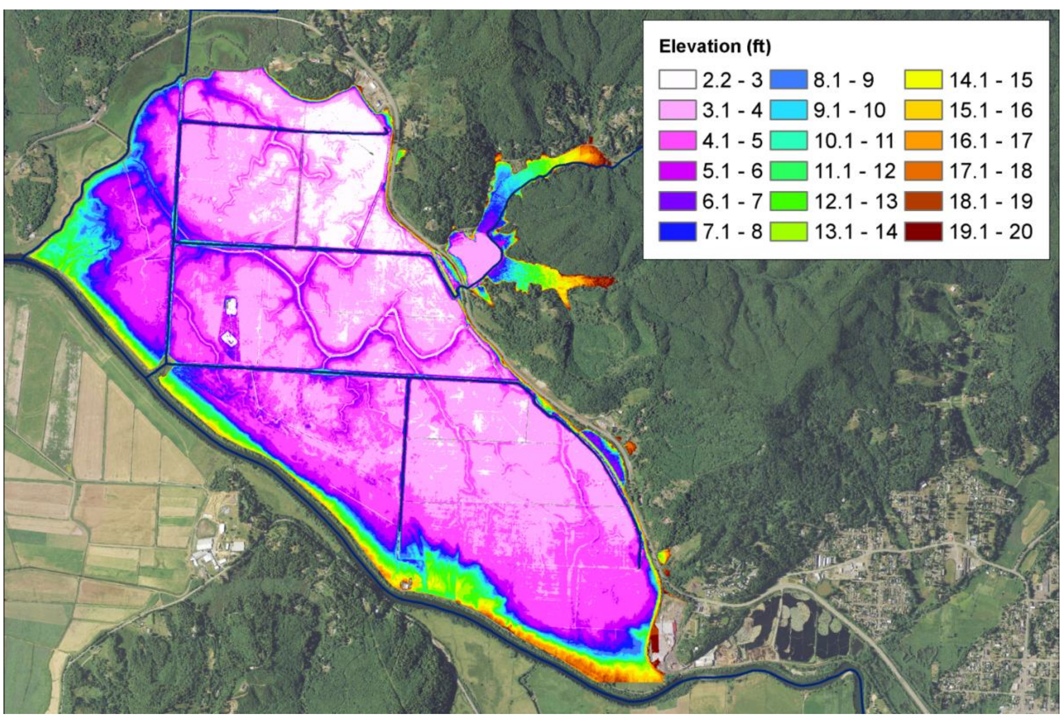

Figure 3: Floodplain topography

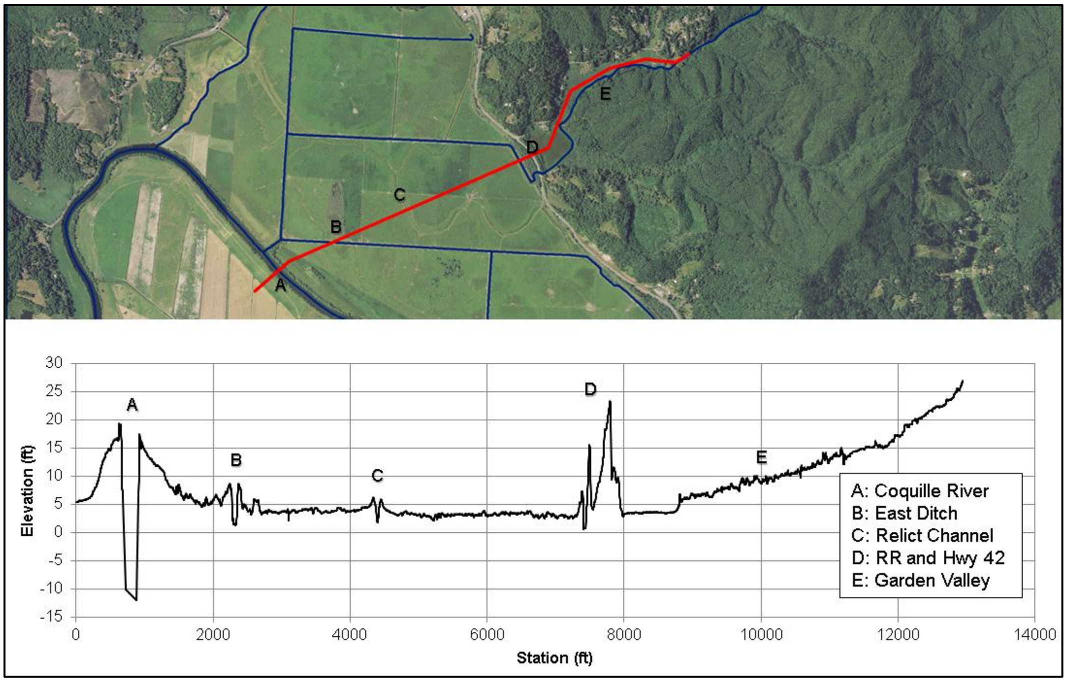

Figure 4: Valley cross-section profile

3.2 Tidal Influence in the Coquille River

The Coquille River at the project site exhibits a mix of riverine and tidal influence in its behavior. Tidal influence is strongest during low river flow. At these times, high tides in the river closely match those in the Pacific Ocean at Bandon (Figure 5, Figure 6). In these conditions, an incoming tide "dams" up the river and forces flow to slow or even reverse, flattening the river slope and reducing velocity. During ebb tide a steeper water surface slope develops as the river again flows downstream and velocities increase. However, even with low tides the river stage remains several feet higher due to the effects of freshwater outflow. As upstream inflows increase low tides at the project site are increasingly muted while high tides are increased only slightly compared to tides at Bandon. As river flows increase further high tide levels also begin to rise. During floods, tidal influence is almost entirely absent and river levels reach elevations of 8 or more feet above high tides at Bandon.

3.3 Water level management in Beaver Slough Drainage District

BSDD interior water levels are regulated by control structures located at the ends of the North and East canals. Each structure consists of twin 8 foot diameter round culverts with top-hinge tidegates. During the winter, no attempt is made to control water levels, although the system still provides some regulation. Small floods overtop the Beaver Slough berm and can fill the district from the lower end. Large floods will overtop the entire natural levee along the river banks. China Camp Creek also inputs higher flows. As a result, the district is commonly flooded over the winter for long periods of time.

Beginning in the spring, the District manages for water level drawdown to allow summer pasture usage. This is dependent on a reduction in Coquille River flows. The range of hydrologic conditions is shown in Figure 5 using a 15 month period of observed water level data collected by BSDD on the river and landward side of the District's outlet structures. Beginning in April 2011 minimum river levels and interior canal levels begin to recede. By May, interior canal levels are generally varying by less than two feet while river levels are showing a strong tidal signature with fluctuation of around 5 to 7 feet (see

Figure 6 also). The East Canal shows a spike in maximum daily water level in August 2011 that is due to the District propping the gates open in order to irrigate the pastures. The first high water occurs in November, followed by a flood in late January 2012 and a series of floods in March and April. Interior water levels during the first event in March do not match the river peak because river levels did not quite reach the elevations required to overtop the Beaver Slough berm system, which is around 14 feet. During the larger events water levels in the district quickly rise to equal those seen in the river. By mid May 2012, water levels are again down to typical low flow levels.

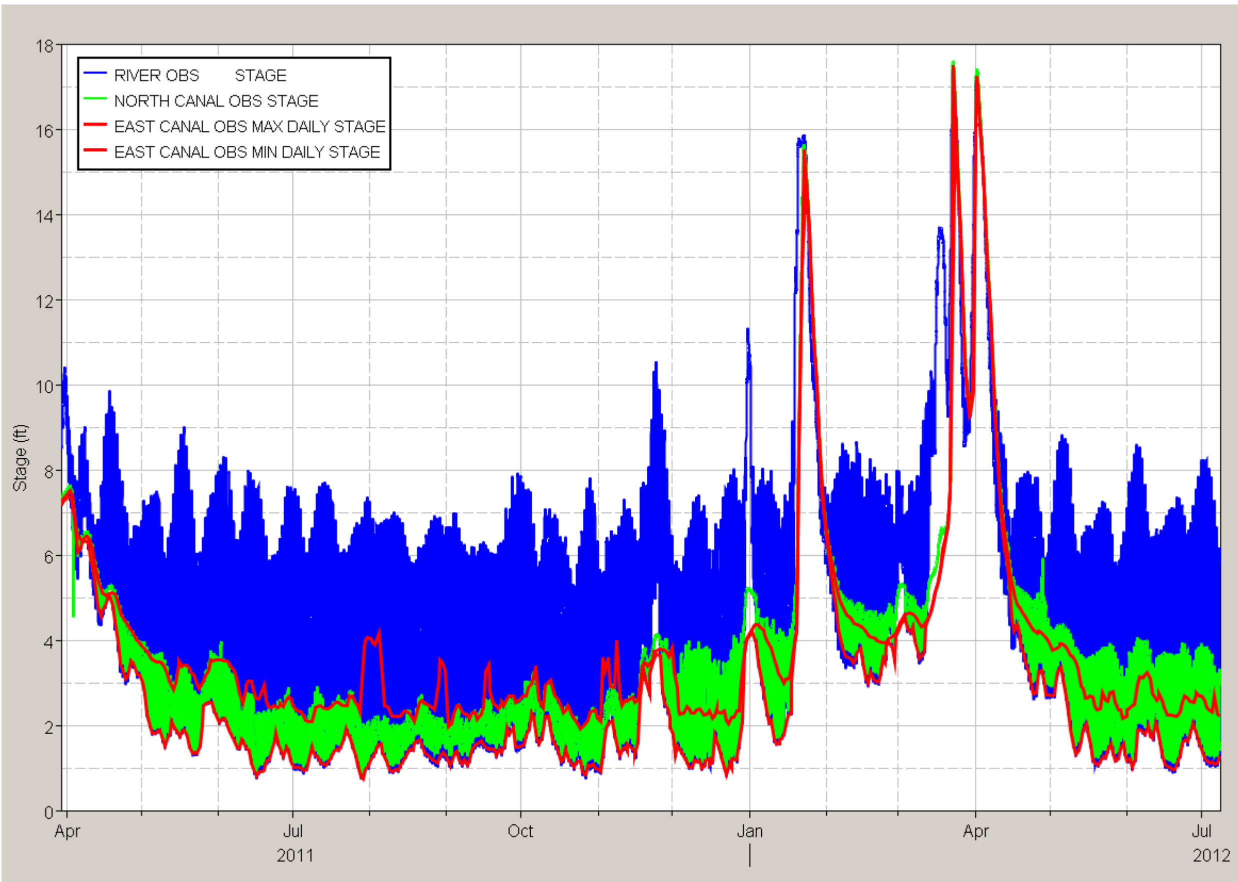

Figure 5: Coquille River and BSDD observed water levels

4 Estimation of flows

Stage and flow data are needed at the downstream and upstream ends, respectively, for the hydraulic modeling. However, flows at the project site in the Coquille River and tributaries are uncertain due to the sparse availability of stream gage records in the watershed. Regressions on historic data, scaling from adjacent gages and application of USGS and National Weather Service data were used to develop flows needed for modeling. Stage data from the nearby NOAA tide gage at Charleston were translated to Bandon. Table 1 lists the gages used in the analysis, Figure 2 shows the locations.

Table 1: Stream and Tide Gages Used in Analysis

Gage	Agency	Period of Record	Drainage Area (sq mi)
14325000 SF Coquille River At Powers	USGS	1916-1924,1926,1928-Present	169
14326500 MF Coquille R Nr Myrtle Point	USGS	1931-1946	305
14327000 NF Coquille R Nr Myrtle Point	USGS	1930-1946,1964-1968, 2013 (1)	282
14320934 Little Wolf Creek Near Tyee	USGS	2008-Present	9
14326510 SF Coquille River At Myrtle Point	USGS	2013 (1)	593
14327055 Coquille River Nr Coquille	USGS	2013 (1)	926
9432780 Charleston Tide Gage	NOAA	1964-Present	n/a
(1) Gage recently re-established, stage only data at this time			

4.1 Coquille River Flows

4.1.1 Low Flows

While there is a newly operational river gage at Coquille (#14327055), the tidal nature of the river makes use of the data to estimate low flows infeasible. Estimates of Coquille River flows at the project site were developed in two different ways.

In the first approach an hourly record at the project site was created through a multi-step process. Mean annual flows for the North Fork (#14327000) and Middle Fork (#14326500) gages were correlated with observed South Fork Coquille River at Powers (#14325000) flows. These three flows were summed and a basin scaling factor applied to account for additional area between the gages and the project site. The equation was applied to current South Fork Coquille River at Powers hourly flow records and lagged by one day to create an estimated flow record for the Coquille River at Coquille.

For the second method hourly stage data from the South Fork Coquille River at Myrtle Point (#14326510) were obtained from the USGS and a NWS synthetic rating curve applied. The flows were then scaled by basin area to estimate flows at the project site.

The two methods resulted in reasonably similar flows given the high uncertainties in the data used – for instance, the April 30 peak flow was 4,400 and 3,900 cfs for the first and second methods respectively. The first method was selected for use in the study based on better calibration of the hydraulic model.

4.1.2 High Flows

Estimation of flood flows at the project site based on similar regression techniques proved to have poor results, in part due to the methods not accounting for the significant attenuation of the flood wave that occurs downstream of the gaging sites on the forks. Applying Coquille River at Coquille stage NWS flows generated from a synthetic rating table also had poor results. As flood modeling of the project will not be completed until the project is better defined no further investigation of high flows was conducted.

The USGS is now operating stage gages on the South Fork and North Fork Coquille Rivers at Myrtle Point. These gages should provide better flood data in the coming years, especially if the USGS is able to obtain some high flow discharge measurements in order to develop an accurate rating curve.

4.2 Local Tributaries

Flow estimates for China Camp Creek and Beaver Creek (this creek drains a 12 square mile watershed that flows into Beaver Slough) were generated by scaling published flows for the USGS Little Wolf Creek near Tyee gage by basin area. This gage, located on a tributary to the Umpqua River around 36 miles northeast of the project site (Figure 2), was selected due to its geographic proximity, similar precipitation and basin size, and availability of recent data. Estimated mean flow for the modeling period was 28 cfs and 5.8 cfs for Beaver Creek and China Camp Creek respectively.

4.3 Groundwater

Substantial amounts of groundwater enter BSDD from the Coquille River, hillside interflow, and other sources. The operation of the drainage system ensures a head difference between the Coquille River and BSDD exists at all but the lowest tides, pulling flows from the river bed and banks into the area. As described in the calibration section, estimation of groundwater inflow was required for calibration of the hydraulic model.

5 Hydraulic Model

HEC-RAS version 4.1 was used to develop an unsteady flow hydraulic model of the project site and lower 25 miles of the Coquille River. Existing condition and multiple with-project alternatives were then simulated.

5.1 Boundary Conditions

The lower boundary condition for the model is a tidal dataset at Bandon (Figure 6). Observed tides at the NOAA Coos Bay Charleston tide gage (Figure 2) were adjusted to Bandon and shifted to NAVD88 vertical datum using published NOAA correction factors.

Coquille River flows are input at the upper end of the model (Figure 6). Flows were estimated using the methods described in the hydrology section. China Camp Creek and Beaver Creek estimated flows were input at the upper ends of their respective reaches. Small constant inflows were added to the upper end of dead-end ditches within the BSDD to represent groundwater inflow (see section 5.8 below).

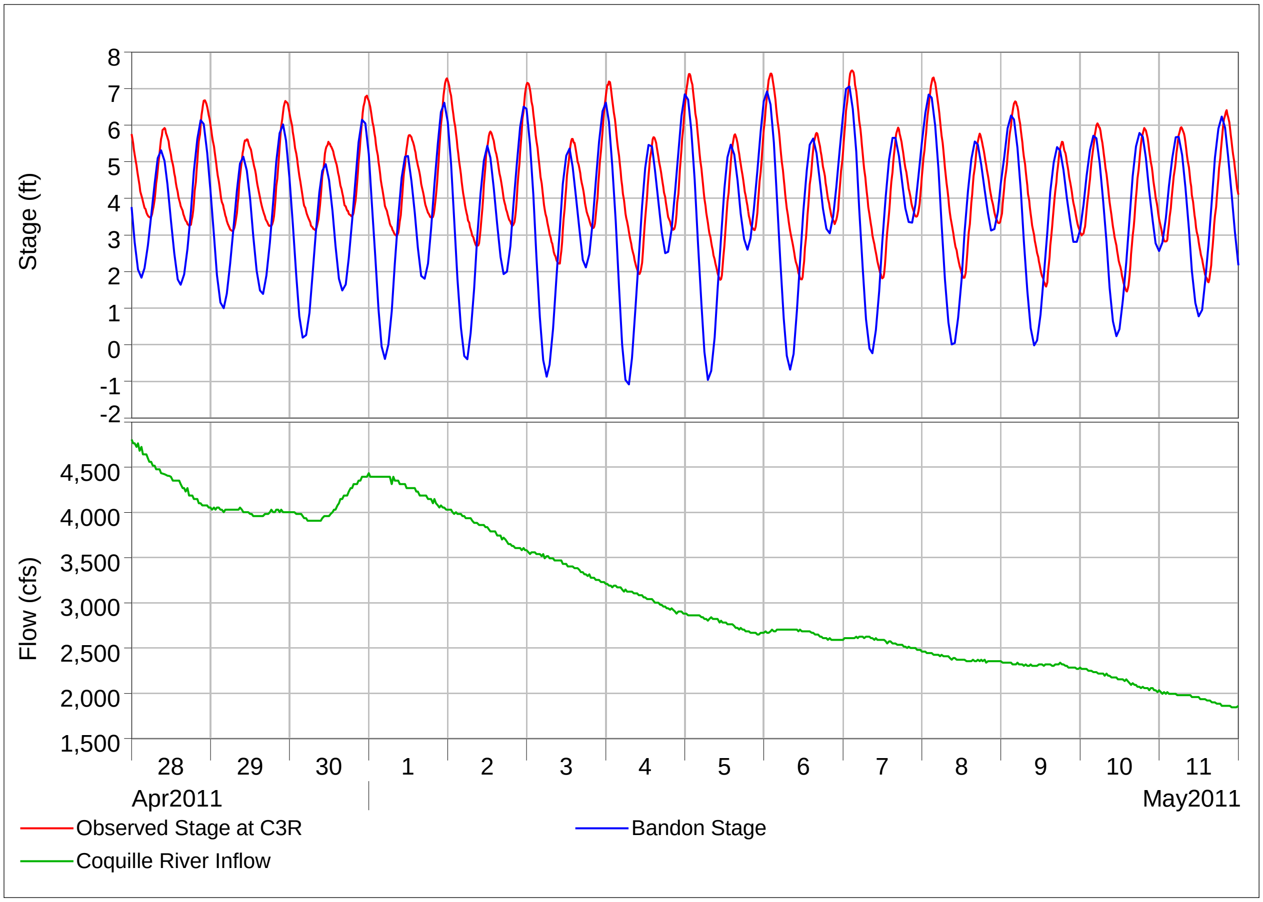

Figure 6: Coquille River model boundary conditions

5.2 Cross-Sections and Channels

Cross-sections were created using LiDAR data for overbank areas merged with bathymetric data and are used to represent the Coquille River, China Camp Creek, Beaver Creek, and the BSDD primary canal network. Twenty-three cross-sections were surveyed in the Coquille River between RM 15 (Riverton) and RM 25. Coquille River and a portion of BSDD canal cross-sections were surveyed by NHC using a survey grade fathometer linked to an RTK GPS unit. Survey of other canal sections used RTK GPS units with manual soundings. Inspection of ditch bathymetric data showed very consistent bottom profiles; this was used to estimate channel sections in the few un-surveyed canal reaches. Two cross-sections were developed at Bandon using NOAA nautical chart bathymetry. Cross-sections between Riverton and Bandon were interpolated.

Channel ‘n’ values (which represent channel roughness in the model) for the Coquille River, China Camp Creek, and the BSDD primary canals were initially defined based on site conditions and then adjusted as described in the calibration section to match observed stage data. The channel ‘n’ value used for the Coquille River and all tributaries except Beaver Creek was 0.031, which was set to 0.025.

Overbank ‘n’ values were applied based on aerial photographs, site visit observations and professional judgment. Most of the floodplain is in pasture, with a narrow forested/brushy riparian zone on the river banks. Pasture ‘n’ values were set to 0.050, and forested/brushy areas to 0.10.

5.3 Storage areas

Storage areas, representing areas that have negligible velocity and water surface slope, were used to represent most of the overbank areas within BSDD. Elevation-volume curves for each storage area were generated from LiDAR data.

5.4 Lateral structures

Lateral structures are used to represent levees and berms that form topographic ridges between various areas in the model domain. Lateral structures were used along the banks of the Coquille River and paralleling the canal network to simulate the spoil berms that form important controls on water levels at certain stages. Lateral structure elevation profiles were generated from LiDAR Data.

5.5 Culverts

All culverts within BSDD connecting to the primary canal network were surveyed by NHC using RTK GPS equipment and included in the model. Culvert diameter, material, presence of tidegates, and invert elevation were recorded. These included the main BSDD tidegates at the Coquille River as well as numerous interior culverts that connect field areas (represented at storage areas) with the main canals (modeled as channel reaches).

5.6 Muted Tidal Regulators

MTRs for the with-project condition were simulated using a combination of culvert and gate control structures. Logic control rules in HEC-RAS were used to simulate MTR operation, allowing the gates to remain open on a flood tide until an interior water level setpoint is reached and then triggering gate closure. MTRs always function as standard tidegates when interior water levels are higher than river levels, e.g. during ebb tides.

5.7 Model Structure

The model structure was set up to facilitate comparing changes between existing and with-project conditions. For the with-project model (Figure 7), the restoration area was changed from storage areas to a reach with cross-sections. Other storage areas had boundaries and elevation-volume curves revised as necessary. The existing outlet structures were replaced with new Unit 1 and 3 structures and various sizes of MTRs for Unit 2, as described in the alternatives analysis.

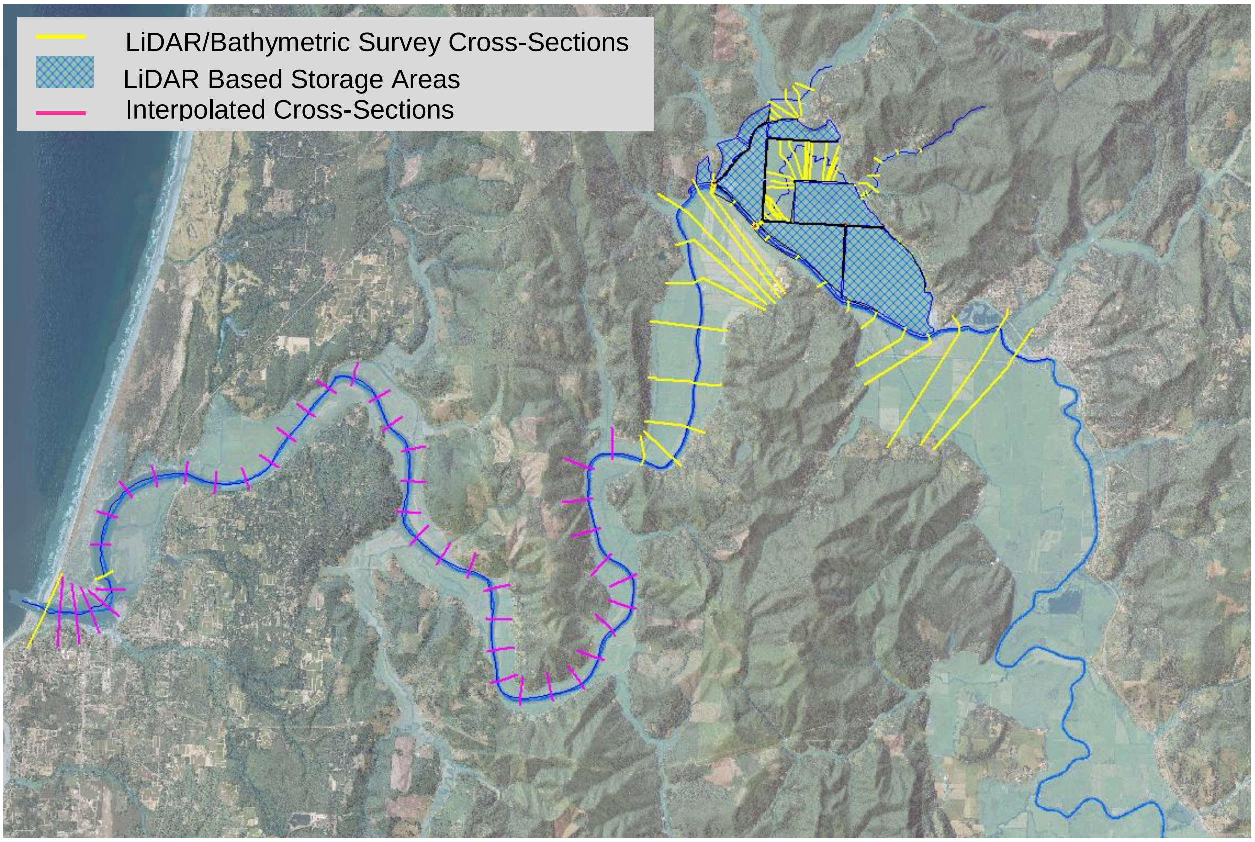

Figure 7: HEC-RAS model structure, with-project condition

5.8 Calibration

Low flow calibration was conducted for the period of April 28 to May 12, 2011. This time window encompasses a full spring-neap tide cycle and also captures a range of Coquille River low flows. Coquille River calibration was accomplished adjusting Mannings ‘n’ values until simulated stages matched observed stages at the BSDD Coquille River gage (Figure 8).

The interior canal system was then calibrated. Varying the constant inflow representing groundwater capture by the drainage network had greatest impact. Overall the interior channels were not sensitive to the Manning’s ‘n’ roughness values used because of the flat channel profiles, and the large conveyance area and storage volumes available in the canals relative to their flows. A total steady state inflow of 36 cfs best fit the observed data (Figure 9 and Figure 10). This flow is much larger than surface flows from China Camp Creek that enter BSDD except under high water conditions.

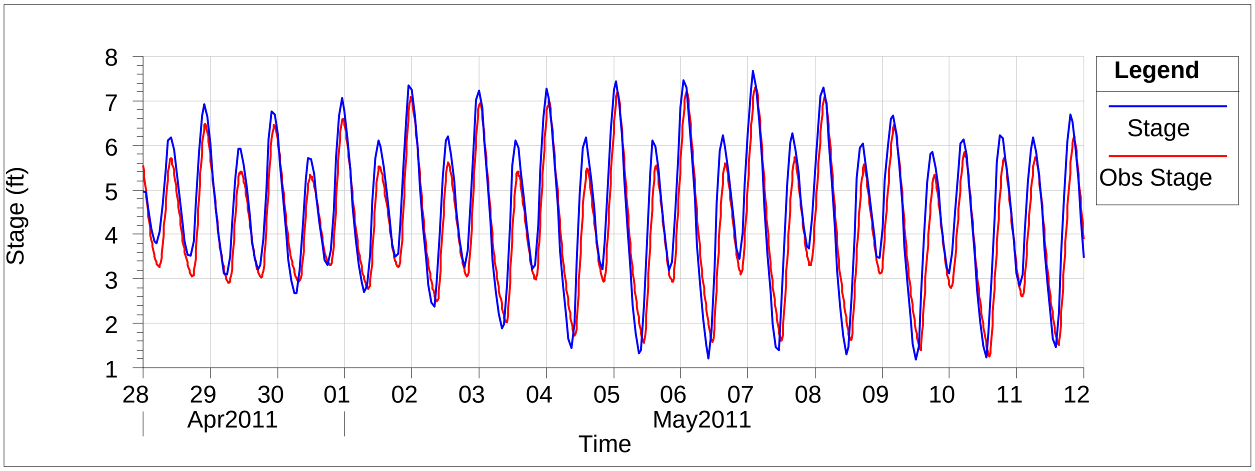

Figure 8: Model calibration results - Coquille River at BSDD outlet

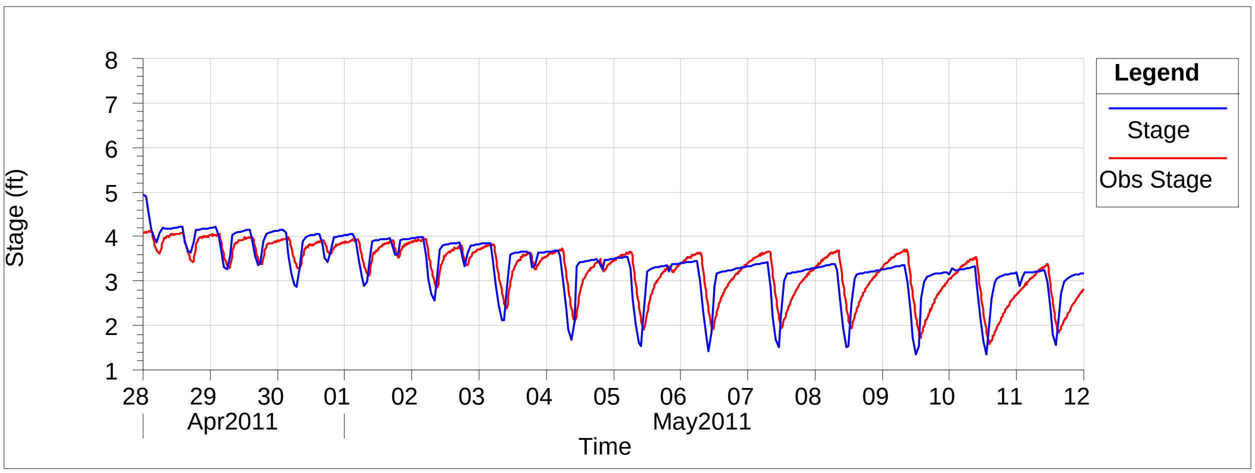

Figure 9: Model calibration results - North Canal/China Camp Creek at Outlet Structure

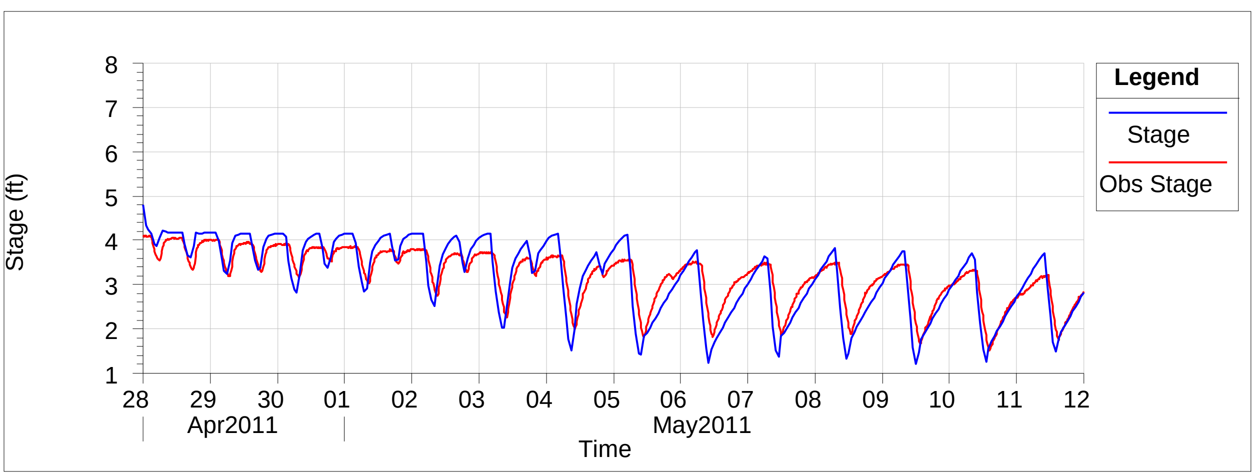

Figure 10: Model calibration results - East Canal at Outlet Structure

6 Alternatives Evaluated

6.1 Model Representation

Evaluation of various alternatives under low flow conditions was conducted using the HEC-RAS model. The same spring-neap tide cycle (April-May 2011) as was used for the calibration was used for evaluation. High flows will be evaluated later as the project design is refined.

The proposed project was represented in the model by changing Unit 2 from a storage area to a reach. Unit 2 reach cross sections were developed by merging LiDAR data and an assumed new China Camp Creek channel. The channel was designed to ensure it was not undersized, allowing water levels in Unit 2 to be fully controlled by the MTR. Lateral structures were added to reflect the new Unit 2 boundary and Unit 1 and 3 storage area volume-elevation curves were adjusted accordingly. A perimeter berm elevation of 7.5 feet was assumed for Unit 2. A range of MTR outlet control structure sizes were evaluated for Unit 2. The Unit 1 replacement control structure was modeled as tidegated twin 8x10 box culverts and the Unit 3 replacement control structure as a single tidegated 8x10 box culvert.

6.2 Project Alternatives

Regulation of the restoration area by the MTRs is controlled by two primary factors. The total gate area provides upper limits on conveyance capacity in and out of the system. The MTR setpoint controls the elevation at which the gates close and prevent further inflow into the restoration area from the Coquille River.

Table 2 summarizes the alternatives evaluated. Alternative MTRs assessed for this project are described by the total gate dimension, i.e., an 8x30 gate consists of three 8 foot high x 10 foot wide gates. Gate invert elevations were set to an elevation of -4 feet to ensure three or more feet of water would be inside the culverts at low tide. One run (referred to as the “Bypass alternative”) was completed with China Camp Creek routed through Unit 1 to the river, rather than through the Unit 2 restoration area. A canal of similar size to the existing East Canal was assumed. This concept would include a control structure to allow full or partial creek diversion into the restoration area at times when Garden Valley flooding issues are not a concern. Full diversion is the same as alternative R3. For modeling purposes this diversion was assumed to be fully closed and all China Camp Creek flow routed through Unit 1.

Table 2: Alternatives Evaluated

Alternative	Total Gate Size	Gate Closure Setpoint Elevation	China Camp Creek Routing
R1	8x40	3.5	Unit 2
R2	8x40	4.0	Unit 2
R3	8x40	4.5	Unit 2
Bypass	8x40	4.5	Unit 1
R4	8x30	4.5	Unit 2
R5	8x30	6.5	Unit 2
R6	10x50	6.5	Unit 2
R7	10x90	6.5	Unit 2

7 Results and Discussion

7.1 Extents and Depths of Inundation

The inundated area and volume of water in Unit 2 will vary through the tide cycle, but will be limited by the MTR setpoint to a maximum elevation. The area of inundation and water volume at various elevations within Unit 2 only (not including Garden Valley) is shown in Figure 11. Data for this figure is based on LiDAR and does not reflect area or volume within channels that may be excavated or allowed to form naturally. Experience with other similar restoration projects has shown that a natural channel network will develop over time and provide wetted channels of some depth even when the water surface elevation is at or below 2 feet.

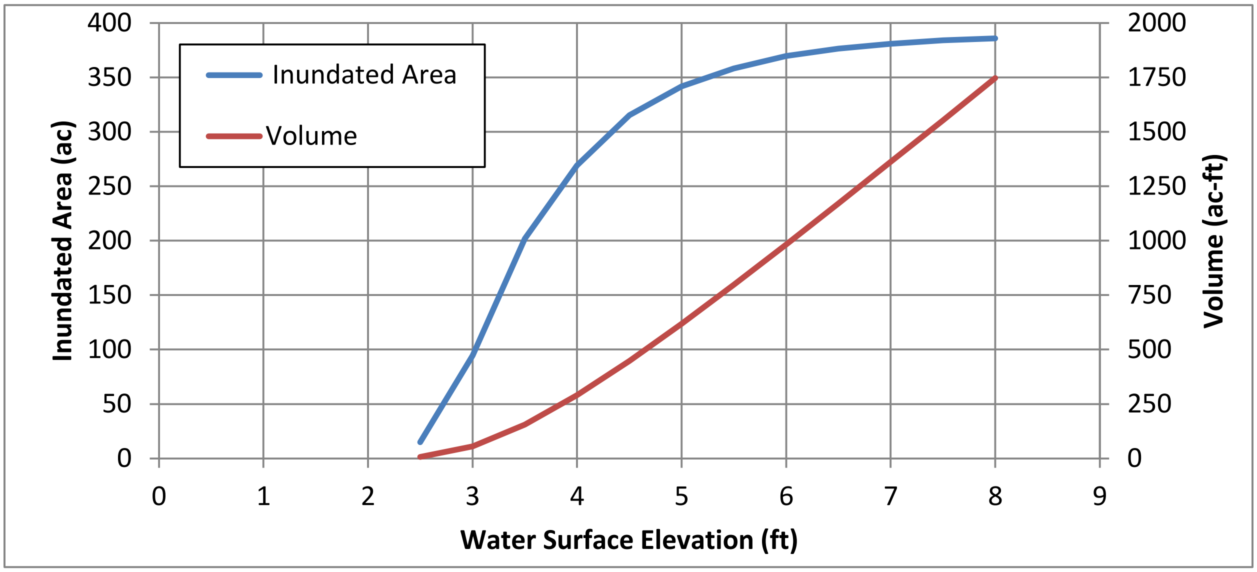

Figure 11: Unit 2 Area and Volume vs. Water Surface Elevation

Figure 12 shows hypothetical inundation at various water levels within the restoration area during late spring and summer months with Units 1 and 3 remaining as drained pastureland. With most of the area at ground elevations of 3 to 5 feet (see Figure 3), flooding will be shallow under any of the setpoint elevations evaluated. Inundation is shown assuming China Camp Creek is routed into the restoration site without control structures, which allows backwater extending upstream under Highway 42 into the lower end of Garden Valley.

During the winter the entire district is inundated at higher water levels. Winter flooding also extends back up into the lower reaches of Garden Valley at higher elevations than any proposed restoration alternatives. Figure 13 shows inundation extents for the entire district during winter conditions at selected levels. Water levels exceeding around 8 feet in elevation (over the top of the Unit 2 perimeter berms) will result in the entire District being uniformly flooded with little difference between existing and with-project conditions.

Figure 12: Inundation extents at various water levels, assuming open connection to Garden Valley

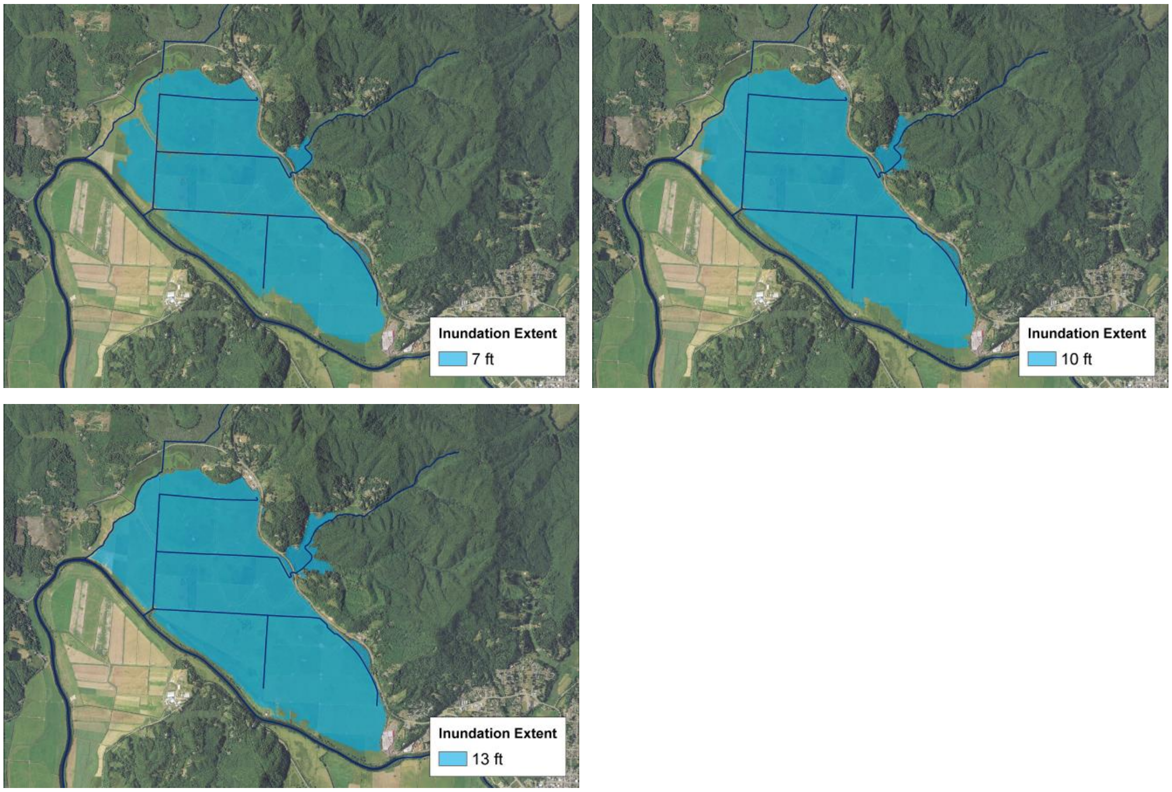

Figure 13: BSDD Selected Winter Inundation Extents

7.2 Restoration Area MTR Culvert Velocities

Culvert velocity durations and gate open time were calculated to support evaluation of fish passage opportunity under various restoration scenarios. Culvert velocity was calculated as the simulated flow through the gate divided by the flow area. Figure 14 shows the results graphically and Table 3 summarizes the same information. Statistics for the Bypass alternative are not presented: they are essentially the same as alternative R3, indicating that China Camp Creek low flows are insignificant compared to tidal fluxes.

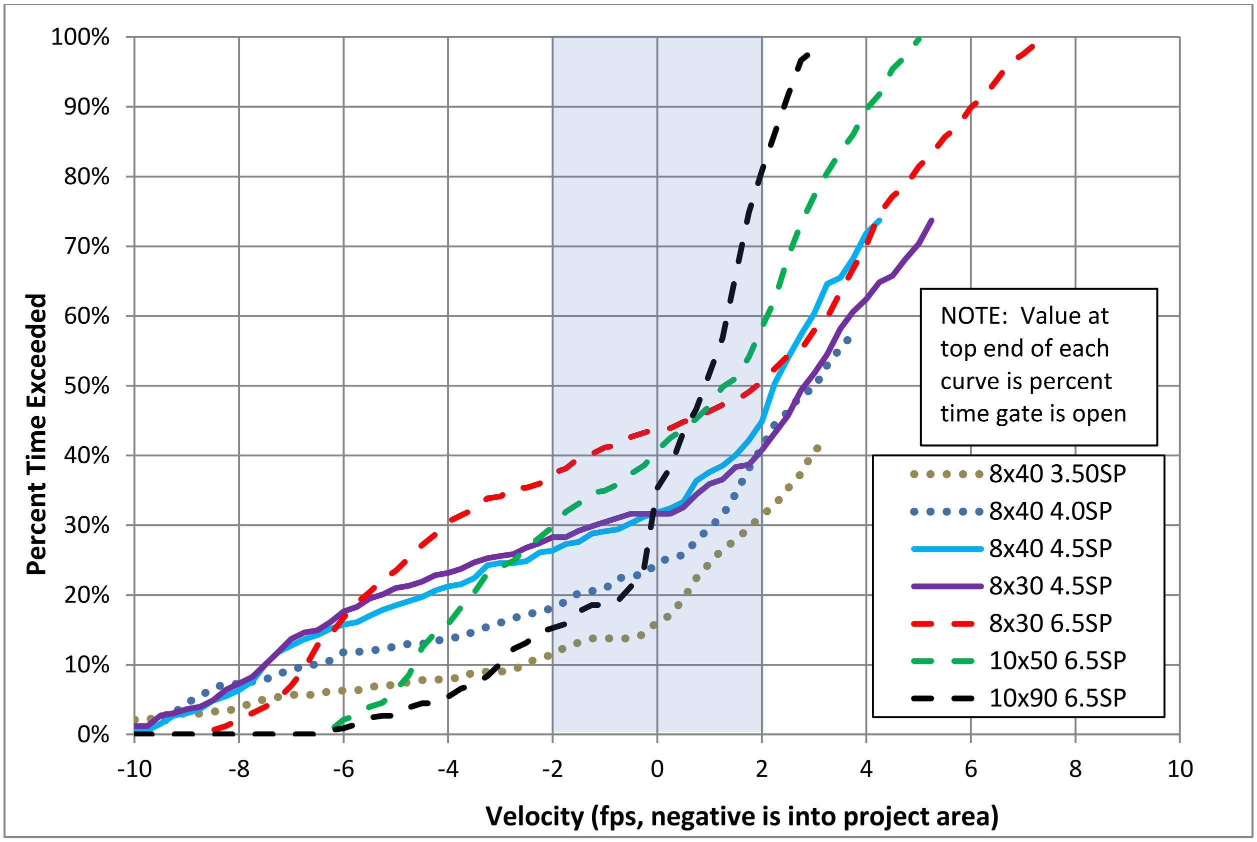

Figure 14: Gate velocity duration and open time curve

Table 3: Gate velocity and open time results

Alt.	Total Gate Size	Gate Closure Setpoint Elevation	Percent Time Gates are Open	Total Percent Time Absolute Velocity < 2 ft/s	Percent Time while Gates are Open Absolute Velocity < 2 ft/s
R1	8x40	3.5	42	20	48
R2	8x40	4.0	58	23	40
R3	8x40	4.5	74	19	25
R4	8x30	4.5	74	12	17
R5	8x30	6.5	100	13	13
R6	10x50	6.5	99.7	29	29
R7	10x90	6.5	99.8	67	67

Gate open time is maximized with higher water level control setpoints, as the gates close later on an incoming tide. Velocity through the gates increases with decreasing total gate size. These higher velocities are caused by head differentials building up between interior and river water levels. Inflow velocities are higher than outflows due to the fact river levels rise more rapidly on the flood tide than they fall on the ebb tide.

7.3 Bypass Alternative

Comparison of the Bypass alternative with alternative R3, which only differs in the routing of China Camp Creek, shows little difference in hydraulic conditions. Flows in and out of the restoration area exceed 1,000 cfs on most tides, so the loss of the few cfs of flow China Camp Creek adds has a negligible impact. Although the bypass alternative routes the 3 sq-mi upland watershed of China Camp Creek into the east canal, Unit 1 hydraulics are changed to only a small degree compared to alternative R3 (Figure 15). Maximum and minimum water levels over a tide cycle remain similar. The dominance of groundwater sourced flow in the drainage network under low flow conditions and large available storage volume make the change due to rerouting the creek into Unit 1 relatively small.

The simulation assumes a standard tidegate is installed on the Unit 1 structure, but with China Camp Creek being routed through Unit 1 under at least some conditions or times permitting agencies may require an MTR or other method to provide better fish access into the creek and upper watershed.

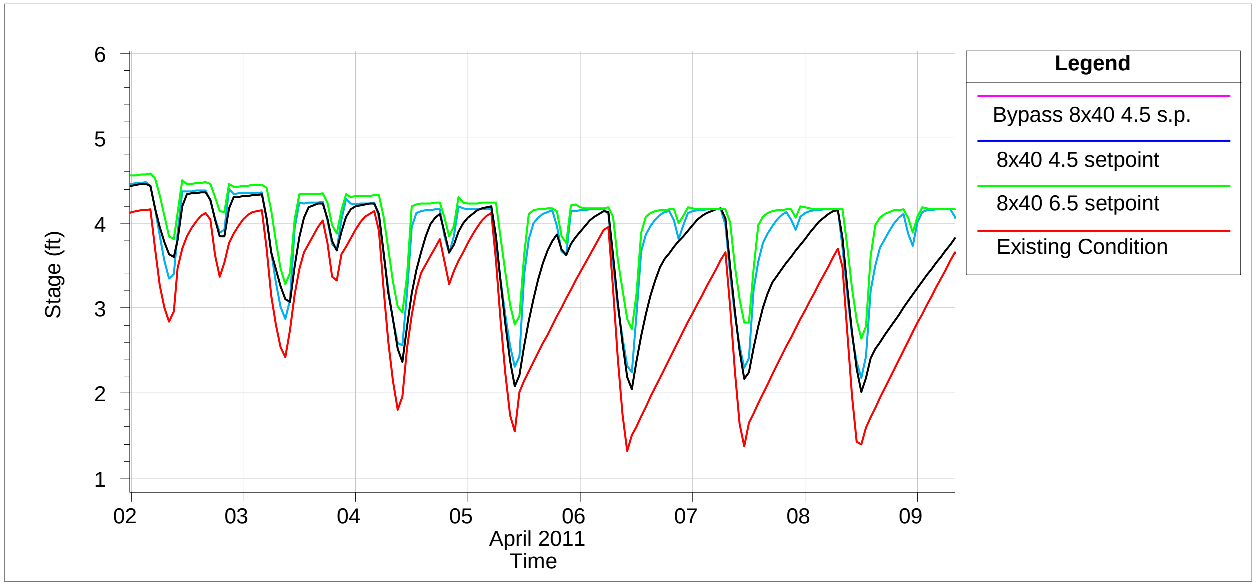

Figure 15: Effects of gate setpoint on Unit 1 water levels

7.4 Effects on adjacent lands and channels

The restoration area contains a significant tidal prism that will be connected to the Coquille River. As such, the volume of water the project will pull in on a flood tide and discharge on an ebb tide is sufficient to change Coquille River hydraulic behavior. The added project discharge results in Coquille River peak ebb tide flows increasing around 15%-30% immediately downstream of the project outlet (Figure 16, Table 4), and the effects continuing to around RM 11 (Figure 17). Coquille flows upstream of the project are essentially unchanged.

The added flow “fills in” the lowest part of the tide cycle downstream of the project, resulting in higher low tides compared to existing conditions (Figure 18, Table 4). Due to the low gradient of the river, this causes a backwater effect upstream of the connection point to around the town of Coquille even though flows are not increased in this reach. The project has negligible effects on high tide levels both upstream and downstream of the project during low river flows. Differences in low tides between existing and with-project conditions will diminish with increasing river flows.

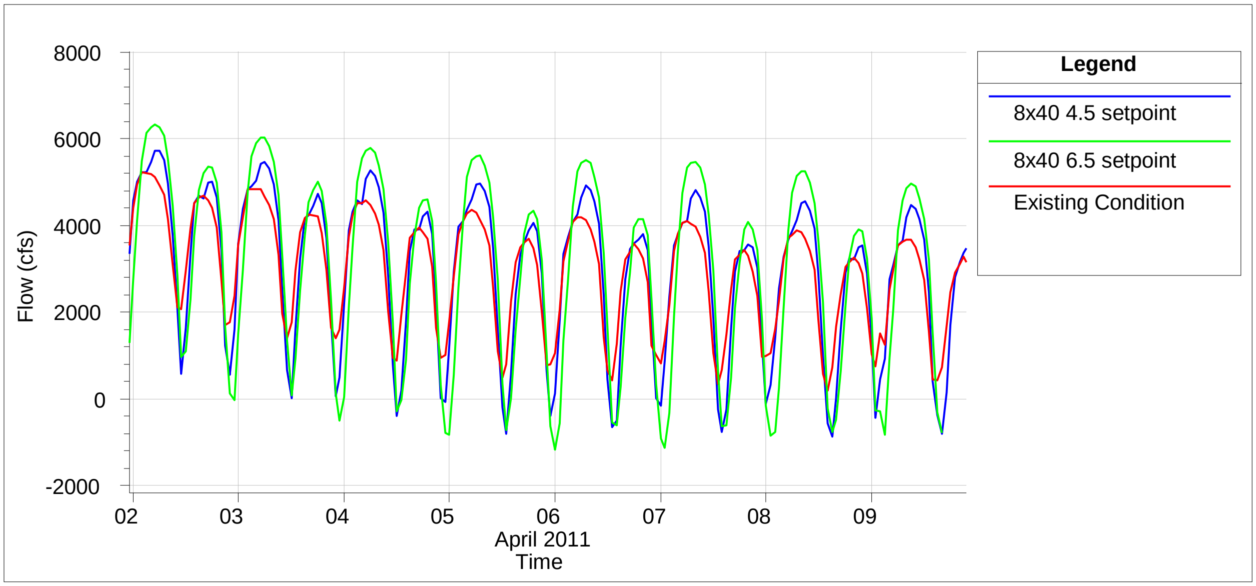

Figure 16: Effects of gate setpoint on Coquille River flows downstream of Project outlet

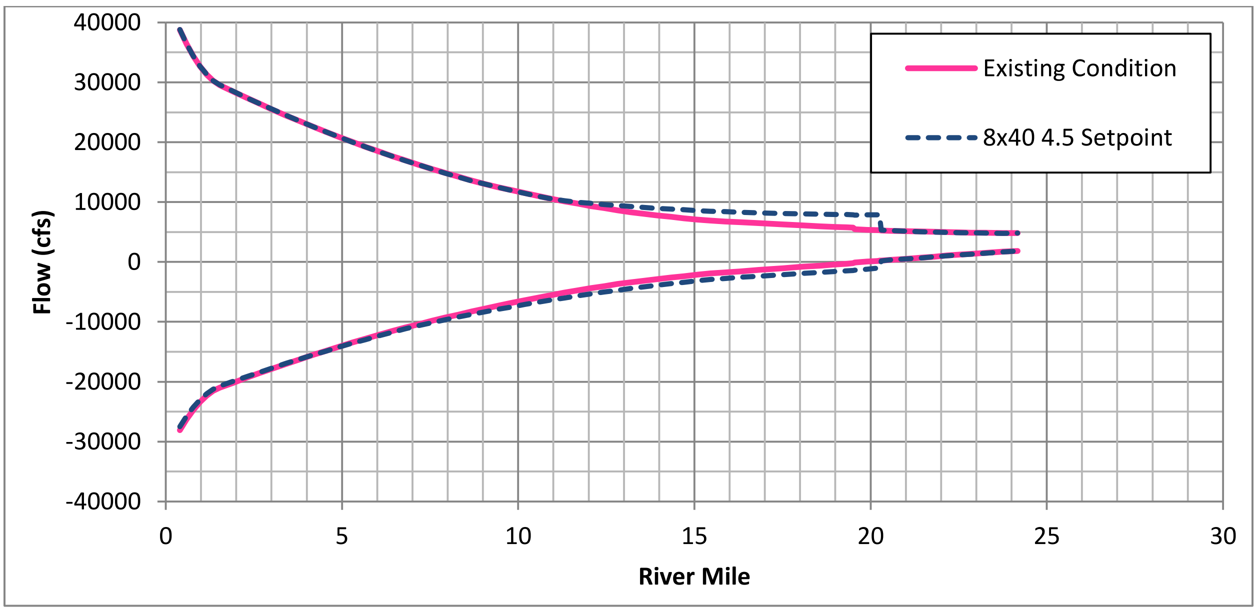

Figure 17: Maximum and Minimum Coquille River Flows for Simulation Period

Table 4: MHHW tidal parameters on the Coquille River at the Project outlet

	Existing Condition (E.C.)	8x40 4.5 Setpoint	8x40 6.5 Setpoint
Flow Amplitude (cfs)	3292	5384	6117
% change from E.C.		64%	86%
Max Ebb Flow (cfs)	4110	4757	5477
% change from E.C.		16%	33%
Min. Low Tide Elev (ft)	1.25	1.83	2.28
Change from E.C. (ft)		+0.58	+1.03

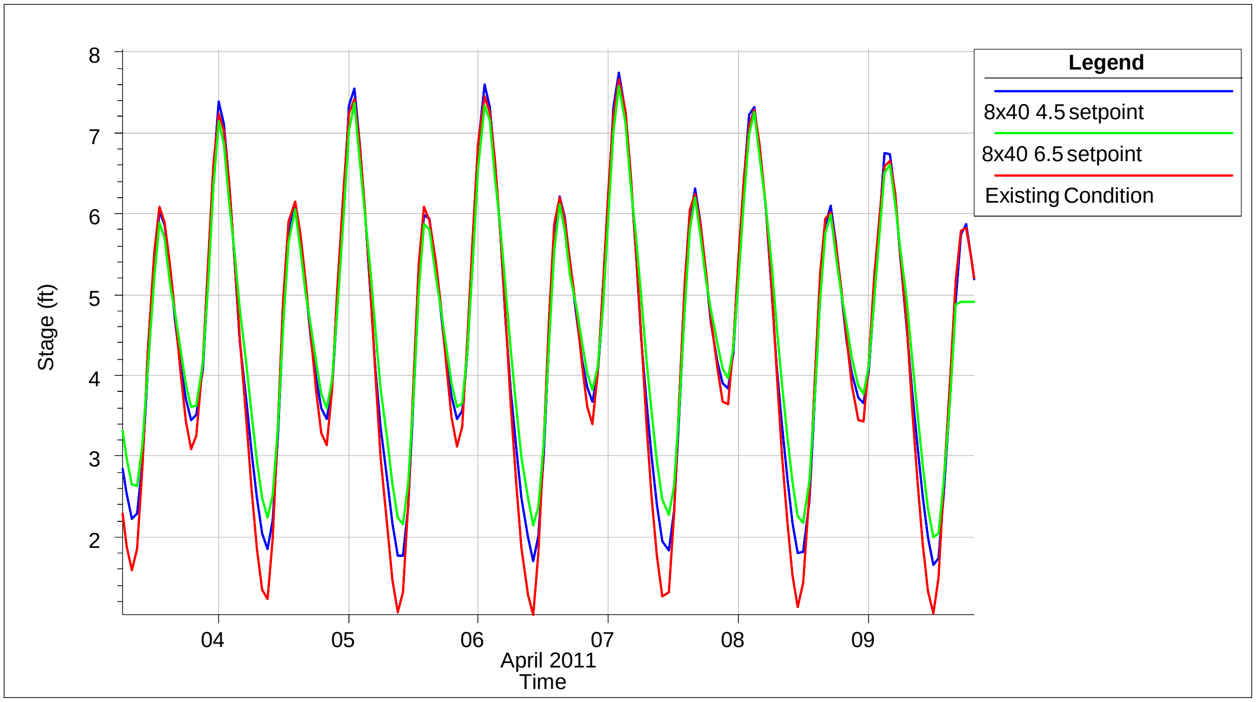

Figure 18: Effects of gate setpoint on Coquille River water levels at the Project

An increase in minimum low tide levels in the river may have consequences on agricultural drainage of adjacent lands. Due to land subsidence it is only during the few hours of the lowest portion of the low tide cycle that the tidegates open and drainage occurs. If low tide levels increase with the proposed project, adjacent lands may have less time to drain. Figure 15 shows the effects on Unit 1 of BSDD; these effects could be similar on other lands adjacent to the project that drain into the Coquille River through tidegates. The increase in low tide minimum elevation and lessened time at the lowest part of the cycle result in increases in water level in the Unit 1 canal. The low point of each drainage cycle represents the absolute minimum elevation the area can be drained to; for the time period shown this increases from elevation 1.4 to 2.7 feet for the 6.5 foot setpoint simulation. Lowering the MTR setpoint to 4.5 feet reduces tidal flux in and out of the restoration area and consequently results in low tide levels closer to existing conditions.

The Bypass alternative results shown in Figure 15 show similar maximum and minimum values over each tide cycle compared to the 4.5 foot setpoint alternative, but slower rates of rise when the tidegates are closed. This is due to assumptions made of the size of the new canal that the bypass alternative will require, which provides storage volume, and that the project will result in a reduction in groundwater inflow to Unit 1. The actual distribution of groundwater inflow is unlikely to be evenly distributed over the district, but no information is available at this time to provide a more detailed picture.

Whether or not a rise in minimum low tide levels causes impacts to pasturelands depends on the relative depth to water from the ground surface and susceptibility of the pasture grasses to a higher water table. For instance, if an area of pasture is four feet above the water table under existing conditions and the project results in the water table rising to three feet below ground it is unlikely productivity will suffer. Indeed, BSDD currently props open the tidegates in summer in order to irrigate their lands, implying that in some areas higher water levels would negate the need for this practice. Lower pasture lands where conditions are marginal already may be impacted by any increase in water table. An evaluation of the potential impacts may be possible by evaluating pasture lands at different elevations within BSDD. A change to water table elevations could then be applied and areas of better, worse, or no change to pasture predicted.

It is possible these increased flows will erode the bed of the river to some degree, increasing cross-sectional area and thereby minimizing any rise through greater conveyance capacity. A cursory review of geotechnical borings taken in BSDD near the river indicate the most likely bed material to be fine sand, which will be mobile even during low flow, tidally dominated conditions. The increase in ebb tide flow results in corresponding increases in velocity and bed shear stress. Numerous studies, including those by Jarrett (1976) and Williams (2002) have positively correlated tidal prism, which can be defined as total ebb tide volume, with channel cross-sectional area. Power function equations used in the studies generally report exponent values near 1.0, indicating approximately linear increase in channel area with an increase in tidal prism. Peak velocities increase by around 25%; applying a typical 1.5 exponent to this indicates sediment transport capacity could increase around 40%. With upstream sediment supply not being changed by the project bed erosion could be expected.

Other evidence does not support the likelihood of channel expansion occurring. Riverine floods result in flood levels eight or more feet above high tides and peak channel velocities and shear stress are much higher than under tidal conditions. Tidal influence is pushed downstream some distance and the high flows persist for days rather than just during each ebb tide. In addition, while tidal flux increases steadily downstream (Figure 17), river cross-sectional area and top width remain relatively constant down to RM 15, which is more consistent with riverine rather than tidal processes. These factors indicate the Coquille River channel form is predominately shaped by floods, not tides. As the project will not change the flood hydrology to any measurable degree, it can be inferred that the channel form will not change either.

There is no indication that aggradation will occur in the river due to the project, but the question of degradation or channel expansion is very complex and unlikely to be fully resolved even with extensive studies. Even if channel expansion was to occur, it could take many years or decades to reach new equilibrium conditions. It is therefore recommended that a conservative assumption of no channel expansion be made for project design purposes.

7.5 Summary of results

- Larger MTR total gate size reduces the time velocities exceed 2 feet/second
- Higher MTR setpoints allow greater gate open time, benefitting fish passage
- Higher MTR setpoints increase total tidal flows both in the restoration area and the Coquille River downstream of the project.
- Increased tidal flows from the project result in higher low tide elevations up and downstream of the site, but little to no change in high tides during low river flow conditions.
- Increased tidal flows in the river may result in channel expansion that could counteract to some degree the increase in low tide levels, but there is a high degree of uncertainty about this.
- China Camp Creek may be routed through either Unit 1 or 2 with little change in hydraulic conditions to either unit.

8 References

Jarrett, J.T., 1976. Tidal Prism – Inlet Area Relationships. GITI Report 3, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS. 55 pp.

Williams, P. B., Orr, M. K. and Garrity, N. J. (2002), Hydraulic Geometry: A Geomorphic Design Tool for Tidal Marsh Channel Evolution in Wetland Restoration Projects. Restoration Ecology, 10: 577–590. doi: 10.1046/j.1526-100X.2002.t01-1-02035.x